Materials Theory Institute

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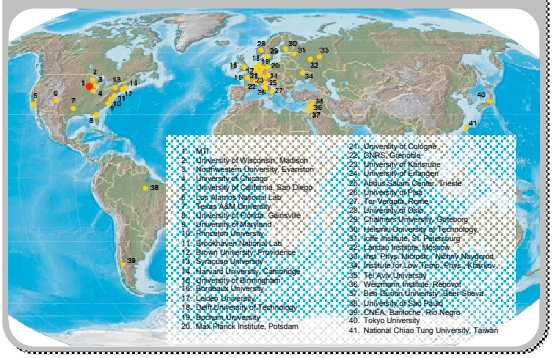
The Materials Theory Institute (MTI) attracts leading theorists in the field of condensed matter physics to collaborate closely with Argonne National Laboratory's experimental and theoretical projects, producing a world-class scientific program on materials theory.
The MTI success hinges on three components:

- **Intense visiting program bringing to Argonne and integrating to Argonne projects the top scientists working on the high impact problems in the area of materials theory**
- **Creating a collaborative network anchored at Argonne, advancing the frontiers of materials theory, and leveraging MTI support**
- **Recruiting best talents to Argonne to form a core staff that supports collaborative projects and carries out world-class research programs**

MTI Collaboration Network

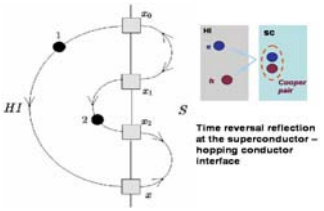


Major Accomplishments and Impact

- **The program carries out intense research in the areas of nanoscience, mesoscopic superconductivity, soft condensed matter, and vortex physics, focusing on properties of disordered and low-dimensional, strongly correlated systems, quantum transport, quantum phase transitions and quantum dynamics, and effects of noise and decoherence.**
- **Publications, 10/1/2004 – 9/30/2005: *25***
  Nature Physics – 1, Phys. Rev. Lett. – 9, Phys. Rev. B – 8, Europhys. Lett. – 4, Appl. Phys. Lett. – 1, Physica B – 1, New J. Phys. – 1. & *25 invited talks*
- **Argonne Fall Workshops on Nanophysics: global nanoscience network**
- **Efficiency: 51 PRLs during October 2001 – September 2005**

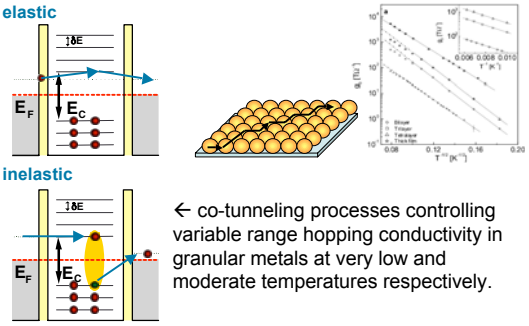
Highlights

Time Reversal Cooper Pair Coherent Reflection



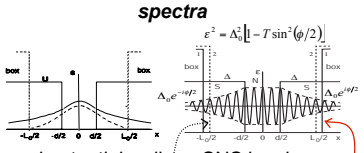
→ Green's functions in hopping conductor
⤫ anomalous Green's functions
□ tunneling Hamiltonian matrix elements

Hopping conductivity in granular metals



← co-tunneling processes controlling variable range hopping conductivity in granular metals at very low and moderate temperatures respectively.

Mesoscopic oscillations of Andreev spectra



usual potential well: small change in energy

SNS in a box: huge change in the state

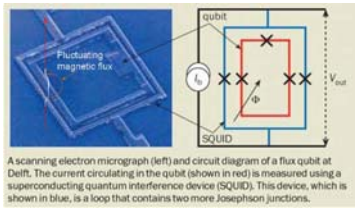
off-resonance: $\sin(k_F L_0) \sim 1$
→ Levels **do** feel box boundaries

resonance: $k_F L_0 = \pi n$:
→ Levels do not feel the box boundaries

Future Work

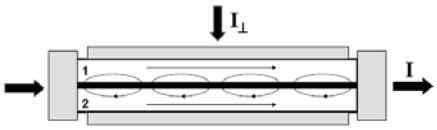
mesoscopic quantum systems – granular conductors, transport in quantum wires, quantum charge and spin transport, noise and decoherence effects, hybrid structures.

Theory of vortex induced noise in qubits



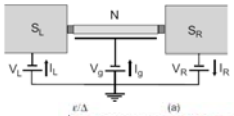
A scanning electron micrograph (left) and circuit diagram of a flux qubit at Delft. The current circulating in the qubit (shown in red) is measured using a superconducting quantum interference device (SQUID). This device, which is shown in blue, is a loop that contains two more Josephson junctions.

Phase textures in superconducting bilayers

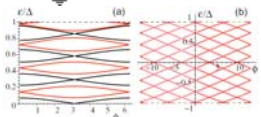


Formation of phase textures in current-carrying bilayer composed of two different SC.
black line: interlayer Josephson contact
gray rectangles: current leads

Quantum pumping



quantum channel with a variable chemical potential



Energy spectrum for a SINIS contact
(- reson., - anti-reson.)

Paths connecting states below $-\Delta$ to those above $+\Delta$

I. S. Beloborodov, A.V. Lopatin, and V. M. Vinokur, Phys. Rev. B 72, 125121 (2005)

http://mti.msd.anl.gov

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